Standardized
Anti-Islanding Test Plan

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1.0 Summary

This plan details testing performed at the Sandia Photovoltaic Systems Evaluation Laboratory (PSEL) to determine the tendency for parallel PV residential utility-interactive (grid-tied) inverters to operate in the absence of a utility which is within normal specifications. This condition is referred to as ***islanding*** or ***run-on***. The tendency of an inverter to run on is a safety concern both for personnel who may be unaware of the additional power feed and for equipment protection, in the case of an attempted out-of-phase line reclosure attempt.

The critical parameter is the time required for the inverter to de-energize when the ac source opens and local loads remain connected.

The utility may be disconnected from the inverter under the following conditions (see figure 1).

1. Case 1: Open utility feeder (leaving the local distribution transformer attached to the inverter)
2. Case 2: Trip local main distribution breaker (removes distribution transformer from the circuit)

Previous testing has demonstrated that different approaches used by some manufacturers tend to interfere with each other and lengthen islanding times. For this reason, these islanding tests will include at least three inverters. One of these inverters will be an inverter that incorporates the Sandia National Laboratories' anti-islanding approach. This approach was developed in cooperation with several US manufacturers of inverters.[1]

2.0 Test Configuration

Figure 1 is a block diagram of the two test configurations. The 120 Vac output of the unit under test is connected to the grid via fused disconnect switches and motor starter contactors. The voltage is stepped up to 480 V by either a 15-kVA or a 50 kVA transformer, as desired. The contactor is used to disconnect the inverter from the grid. Local resistive, capacitive, inductive, and motor loads are connected at the output of the inverter and can be adjusted to the level

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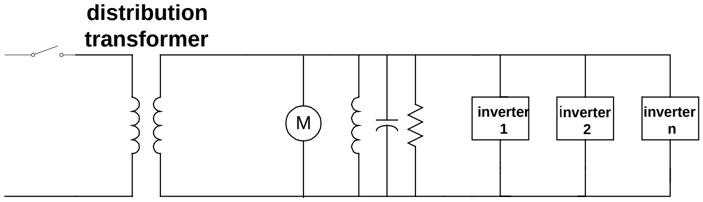
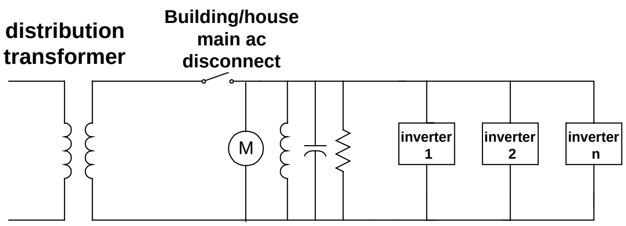
[1] Results of Sandia National Laboratories Grid-Tied Inverter Testing, G. A. Kern, et al. The 2nd World Conference and Exhibition on Photovoltaic Energy Conversion Vienna, Austria, June 1998.

required for the test. The inverters are powered by dc from a PV array which is configured to produce close to the unit's maximum power rating.

The test includes three inverters. One is a control inverter (clearly it needs to be a non-islanding inverter). The other two are identical versions of the inverter being evaluated.



case 1: contactor on utility side of transformer



case 2: contactor on inverter side of transformer

Figure 1: Test Configuration

Figure 2 shows the instrumentation configuration. The following five parameters are recorded prior to and during the islanding event:

1. Voltage (V)
2. Current (A)
3. THD (0 to 10 Vdc analog signal from the AI Eval board)
4. frequency (0 to 10 Vdc analog signal from the AI Eval board)
5. serial status data from the AI Eval board

The power (W) is calculated by integrating 15 cycles of the Vac and Iac for those acquisitions prior to the event. The reactive power (vars) and the power factor are calculated from the volt-amperes and the watts.

These tests are designed to identify problems with islanding and as such they tend to be more "worst case" than "typical" case. Thus, the transformer used has a rated VA capacity of approximately twice the inverter output and the motor is attached to a significant flywheel. This testing will be described in greater detail in SAND 98-1684, "Development and Testing of an Approach to Anti-islanding in Utility-Interconnected Photovoltaic Systems," which will be available at this WEB site in 1999.

3.0 Test Procedures

Inverter time to trip and/or shutdown is recorded for different load configurations described below.

Test #	Test Description	Inverter	Transformer/size*	Longest t (disc)	Pload/Pgen (longest t) (disc)	I grid (longest t) (disc)	Last inverter disconnect	Last full cycle frequency reading	Last full cycle voltage reading
1A	resistive (Pgen/Pload =1)	Inv 1	none						
		Inv 2	none						
		Inv 3	none						
		All 3	none						
1B	resistive (Pgen/Pload =.8)	All 3	none						
1C	resistive(Pgen/Pload =1.2)	All 3	none						
2A	case 1A to match VARs	All 3	none						
2B	RL , matched kVA, pf=.9	All 3	none						
2C	RL , matched kVA, pf=.7	All 3	none						
2D	RC, matched kVA, pf=.9	All 3	none						
2E	RC, matched kVA, pf=.7	All 3	none						
2F	LRC, 60Hz res, Pgen=Pload, $Q \approx 1$	All 3	none						
2G	LRC, 60Hz res, Pgen=Pload, $Q \approx 3$	All 3	none						
2H	LRC, 60Hz res, Pgen=Pload, $Q \approx 4$	All 3	none						
2I	LRC, 60Hz res, Pgen=Pload, $Q \approx 5$	All 3	none						
2J	LRC, 60Hz res, Pgen=Pload, $Q \approx 6$	All 3	none						
2K	LRC, 60Hz res, Pgen=Pload, $Q \approx 7$	All 3	none						
2L	motor with C,.5 hp grinder, pf=1	All 3	none						
3A	move contactor to primary, worst case from tests 1	All 3	200%						
5F	move contactor to primary, RC (inductance from transformer), pf=1, (Pgen/Pload=1)	All 3	200%						
6A	2kVA transformer as load with 50Ω attached. Enough caps for pf = .28	All 3	200%						
6B	2kVA transformer as load with 200Ω attached. Enough caps for pf = .28	All 3	200%						
6C	Repeat 2E with transformer	All 3	200%						
6D	Repeat 2F with transformer	All 3	200%						
6E	Repeat 2G with transformer	All 3	200%						
6G	Repeat 2H with transformer	All 3	200%						
6H	Repeat 2I with transformer	All 3	200%						
6I	Repeat 2J with transformer	All 3	200%						
6K	Repeat 2K with transformer	All 3	200%						

*Note: Transformer size is rated as a percentage of maximum available PV power.

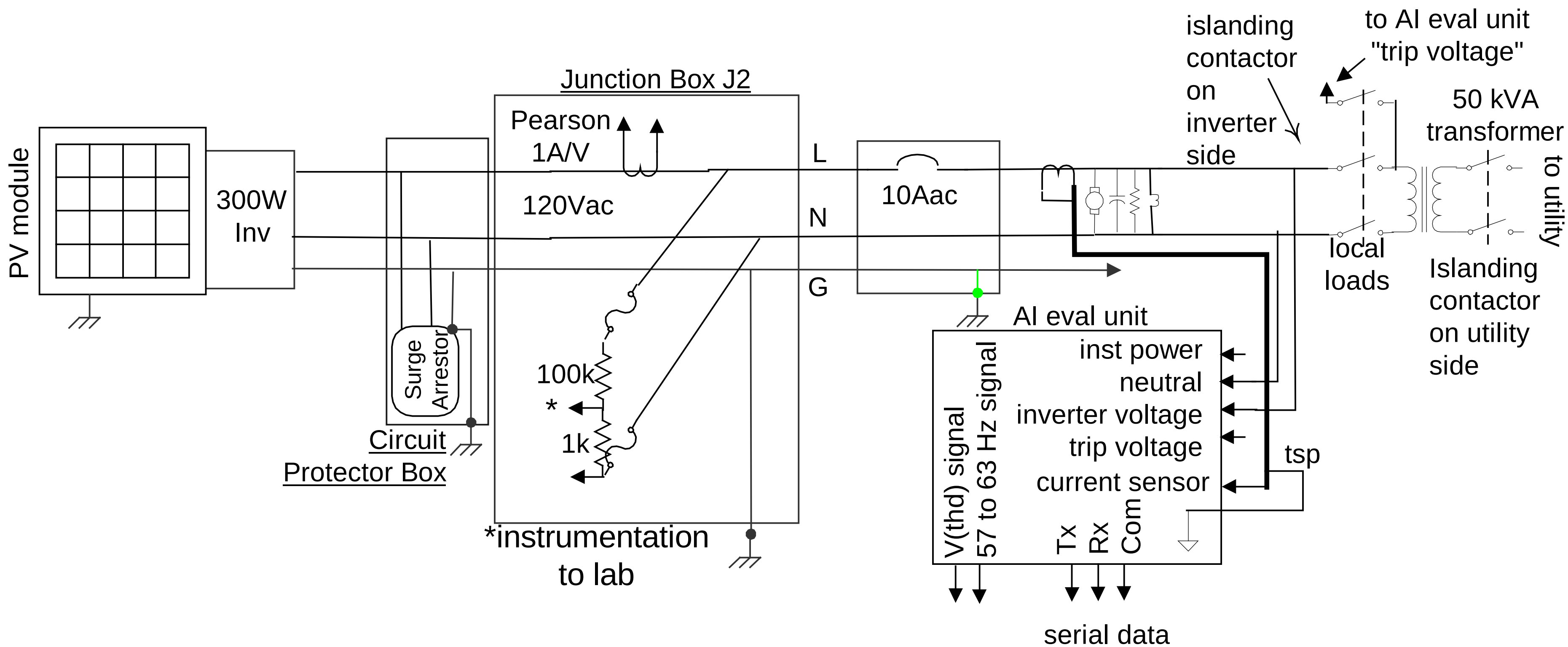


Figure 2: Instrumentation as Configured for
the Module Scale Inverter Evaluation